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(19) **United States**

(12) **Patent Application Publication**
WANG et al.

(10) **Pub. No.: US 2022/0407217 A1**

(43) **Pub. Date: Dec. 22, 2022**

(54) **ANTENNA APPARATUS AND ELECTRONIC DEVICE**

Publication Classification

(71) Applicant: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen (CN)

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/36 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/50 (2006.01)

(72) Inventors: **Hanyang WANG**, Reading (GB); **Yuanpeng LI**, Shenzhen (CN); **Dawei ZHOU**, Shenzhen (CN); **Le CHANG**, Shenzhen (CN); **Hai ZHOU**, Reading (GB)

(52) **U.S. Cl.**
CPC *H01Q 1/243* (2013.01); *H01Q 1/36* (2013.01); *H01Q 1/48* (2013.01); *H01Q 1/50* (2013.01)

(73) Assignee: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen (CN)

(57) **ABSTRACT**

(21) Appl. No.: **17/773,381**

(22) PCT Filed: **Oct. 30, 2020**

(86) PCT No.: **PCT/CN2020/125466**

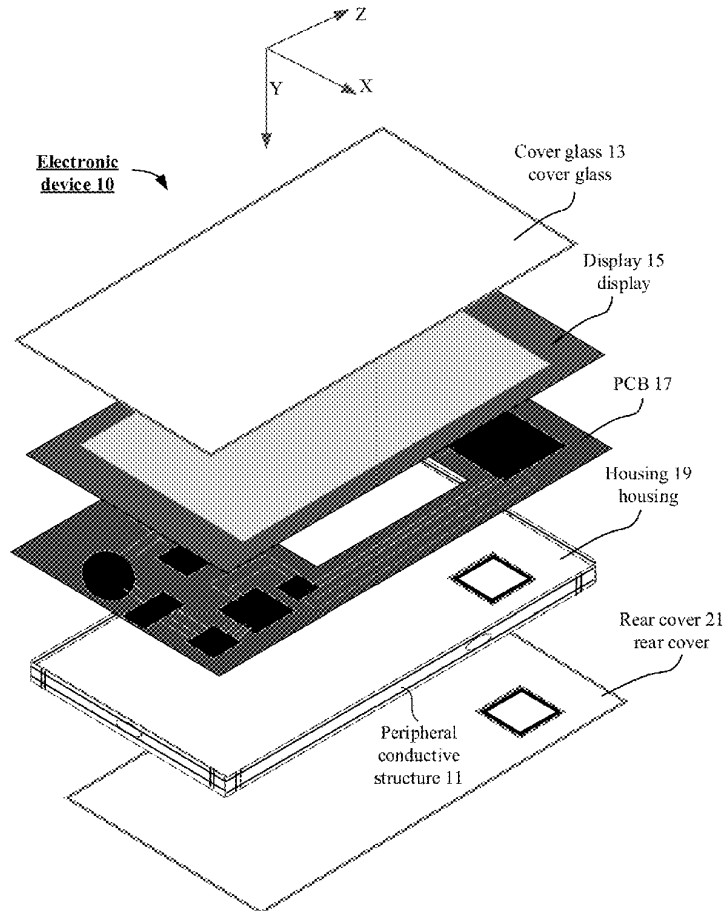
§ 371 (c)(1),

(2) Date: **Apr. 29, 2022**

A single feed antenna design is conducted on a radiator of a specific shape (for example, a strip radiator or a slot radiator) to excite a plurality of antenna modes. For example, performing a feed design on a strip radiator may excite a CM wire antenna mode and a DM wire antenna mode. For another example, performing a feed design on a slot radiator may excite a CM slot antenna mode and a DM slot antenna mode. The antenna design may be used to cover a plurality of frequency bands when an antenna is miniaturized.

(30) **Foreign Application Priority Data**

Oct. 31, 2019 (CN) 201911054822.7





US 20220407224A1

(19) **United States**

(12) **Patent Application Publication**
Hsu et al.

(10) **Pub. No.: US 2022/0407224 A1**

(43) **Pub. Date: Dec. 22, 2022**

(54) **WIRELESS RADIATION MODULE AND ELECTRONIC DEVICE USING THE SAME**

(52) **U.S. Cl.**
CPC **H01Q 3/247** (2013.01); **H01Q 21/08** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/241** (2013.01)

(71) Applicant: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

(72) Inventors: **Cho-Kang Hsu**, New Taipei (TW);
Min-Hui Ho, New Taipei (TW)

(57) **ABSTRACT**

(21) Appl. No.: **17/839,717**

(22) Filed: **Jun. 14, 2022**

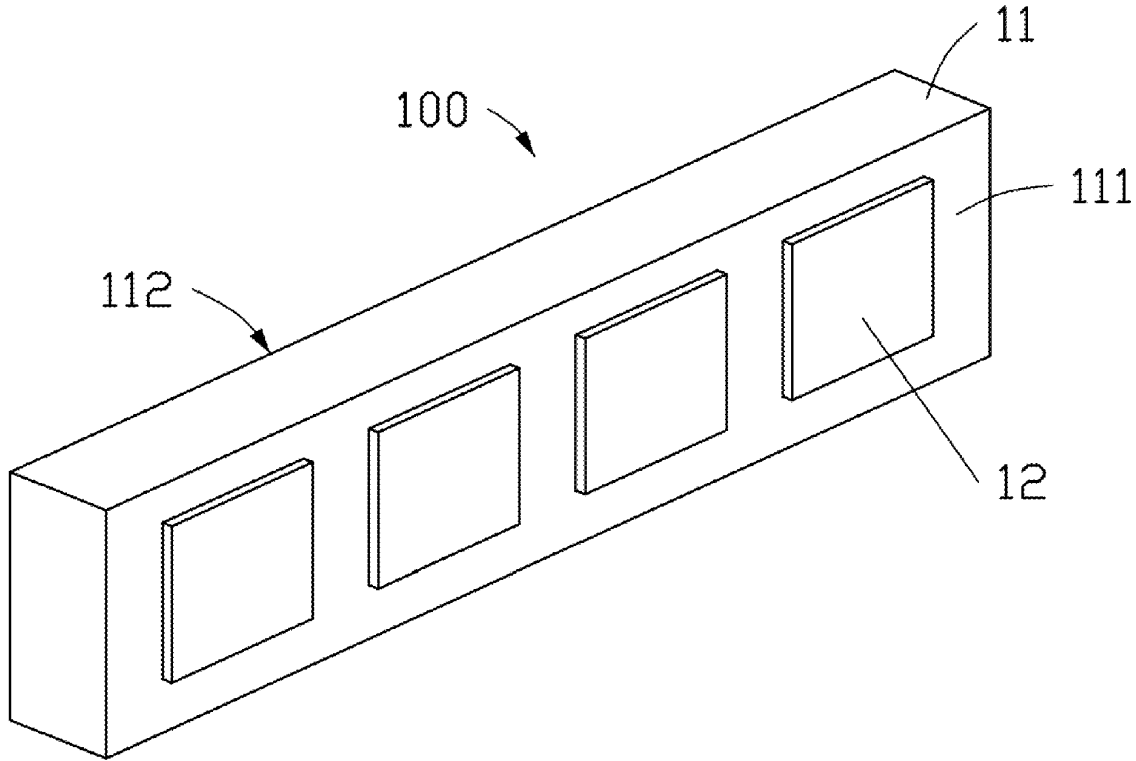
A wireless radiation module with multiple miniaturized antennas receiving signals from multiple switchable feed points for enhanced frequency ranges includes a substrate, a radiation portion, and an active circuit. The radiation portion is spaced apart from a radiator. The radiation portion generates multiple radiation modes through coupling with the radiator, and signals are transmitted and/or received from the radiator. The active circuit is electrically connected to the radiation portion for switching between multiple radiation modes of the radiation portion. The wireless radiation module can operate in multiple radiation modes, and cover multiple frequency bands, to increase a bandwidth and have an improved antenna efficiency. The present disclosure also provides an electronic device with the wireless radiation module.

(30) **Foreign Application Priority Data**

Jun. 21, 2021 (CN) 202110688131.3

Publication Classification

(51) **Int. Cl.**
H01Q 3/24 (2006.01)
H01Q 21/08 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/24 (2006.01)





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(19) **United States**

(12) **Patent Application Publication**
HSU et al.

(10) **Pub. No.: US 2022/0407227 A1**

(43) **Pub. Date: Dec. 22, 2022**

(54) **ANTENNA STRUCTURE AND ELECTRONIC DEVICE USING THE SAME**

(52) **U.S. Cl.**
CPC **H01Q 5/35** (2015.01); **H01Q 3/22** (2013.01); **H01Q 15/24** (2013.01); **H01Q 1/241** (2013.01)

(71) Applicant: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

(72) Inventors: **CHO-KANG HSU**, New Taipei (TW); **MIN-HUI HO**, New Taipei (TW)

(57) **ABSTRACT**

(21) Appl. No.: **17/839,709**

(22) Filed: **Jun. 14, 2022**

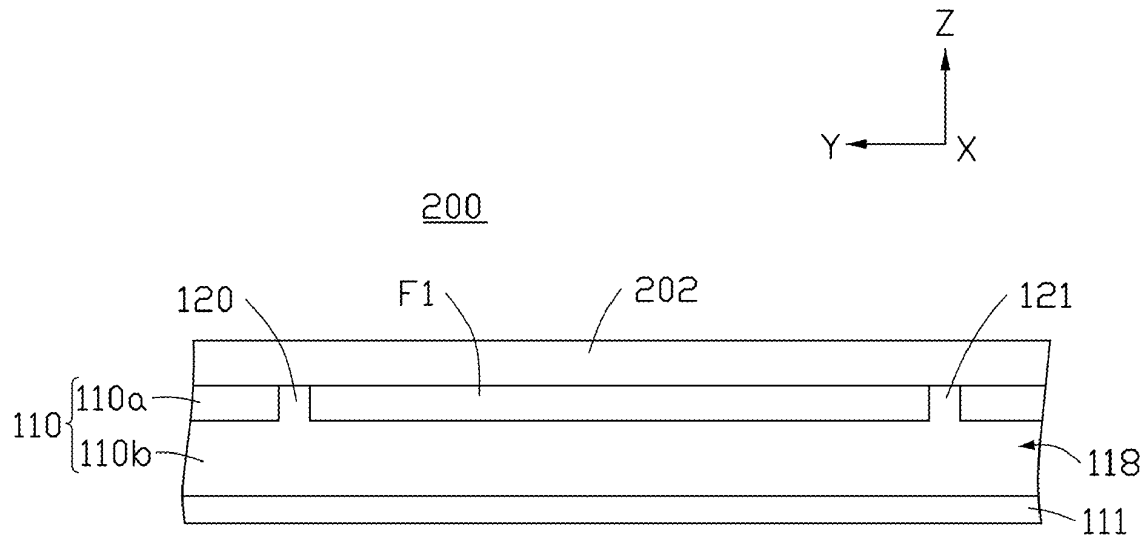
(30) **Foreign Application Priority Data**

Jun. 21, 2021 (CN) 202110688067.9

An antenna structure includes at least one radiation portion, first, second, and third feed sources, and first and second grounding portions. The at least one radiation portion is formed by a partial portion of the metal frame of the electronic device, the portion being defined by gaps. The first to third feed sources are arranged at intervals and are electrically connected to the at least one radiation portion in such a way as to make the radiation portion form a plurality of antennas. The first end of the first grounding portion is electrically connected to the radiation portion, the second end of the first grounding portion is grounded, the first end of the second grounding portion is electrically connected to the radiation portion, and the second end of the second grounding portion is grounded. The present disclosure also provides an electronic device with the antenna structure.

Publication Classification

(51) **Int. Cl.**
H01Q 5/35 (2006.01)
H01Q 3/22 (2006.01)
H01Q 15/24 (2006.01)
H01Q 1/24 (2006.01)





US 20220407229A1

(19) **United States**

(12) **Patent Application Publication**
HARPER

(10) **Pub. No.: US 2022/0407229 A1**

(43) **Pub. Date: Dec. 22, 2022**

(54) **CHASSIS ANTENNA**

(52) **U.S. Cl.**

(71) Applicant: **Microsoft Technology Licensing, LLC,**
Redmond, WA (US)

CPC **H01Q 7/005** (2013.01); **H01Q 1/241**
(2013.01)

(72) Inventor: **Marc HARPER,** Snohomish, WA (US)

(57) **ABSTRACT**

(73) Assignee: **Microsoft Technology Licensing, LLC,**
Redmond, WA (US)

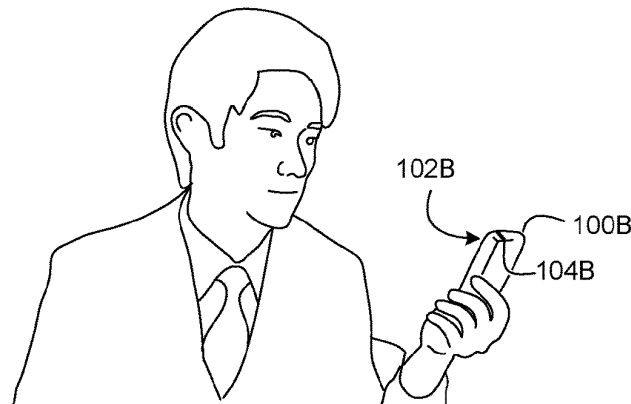
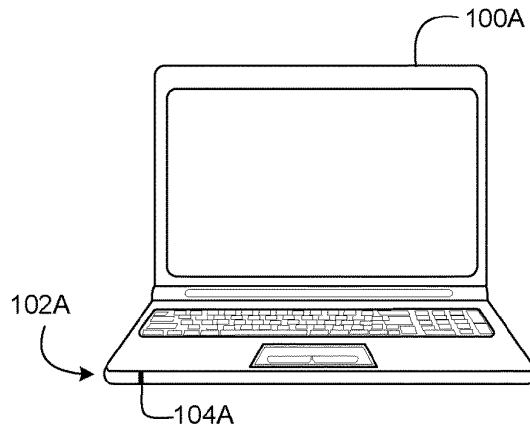
(21) Appl. No.: **17/354,615**

(22) Filed: **Jun. 22, 2021**

Examples are disclosed that relate to an antenna formed in a chassis of a device. One example provides a wireless device comprising a chassis and a chassis antenna formed at least in part by a dielectric gap between a body of the chassis and the chassis antenna, where a first end of the chassis antenna is defined by a cut-out in the chassis and where a second end of the chassis antenna being conductively connected to a body of the chassis. The wireless device further comprises a modem, and a coupled feed connected to the modem and capacitively coupled to the chassis antenna.

Publication Classification

(51) **Int. Cl.**
H01Q 7/00 (2006.01)
H01Q 1/24 (2006.01)





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(19) **United States**

(12) **Patent Application Publication**
GHOSH et al.

(10) **Pub. No.: US 2022/0407231 A1**

(43) **Pub. Date: Dec. 22, 2022**

(54) **WIDEBAND ELECTROMAGNETICALLY COUPLED MICROSTRIP PATCH ANTENNA FOR 60 GHZ MILLIMETER WAVE PHASED ARRAY**

Publication Classification

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/42 (2006.01)
H01Q 13/10 (2006.01)

(52) **U.S. Cl.**
 CPC *H01Q 9/045* (2013.01); *H01Q 1/422* (2013.01); *H01Q 13/10* (2013.01)

(71) Applicant: **INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR**,
Kharagpur (IN)

(72) Inventors: **Saswati GHOSH**, Kharagpur (IN);
Debarati SEN, Kharagpur (IN)

(21) Appl. No.: **17/780,554**

(22) PCT Filed: **Nov. 28, 2020**

(86) PCT No.: **PCT/IB2020/061249**

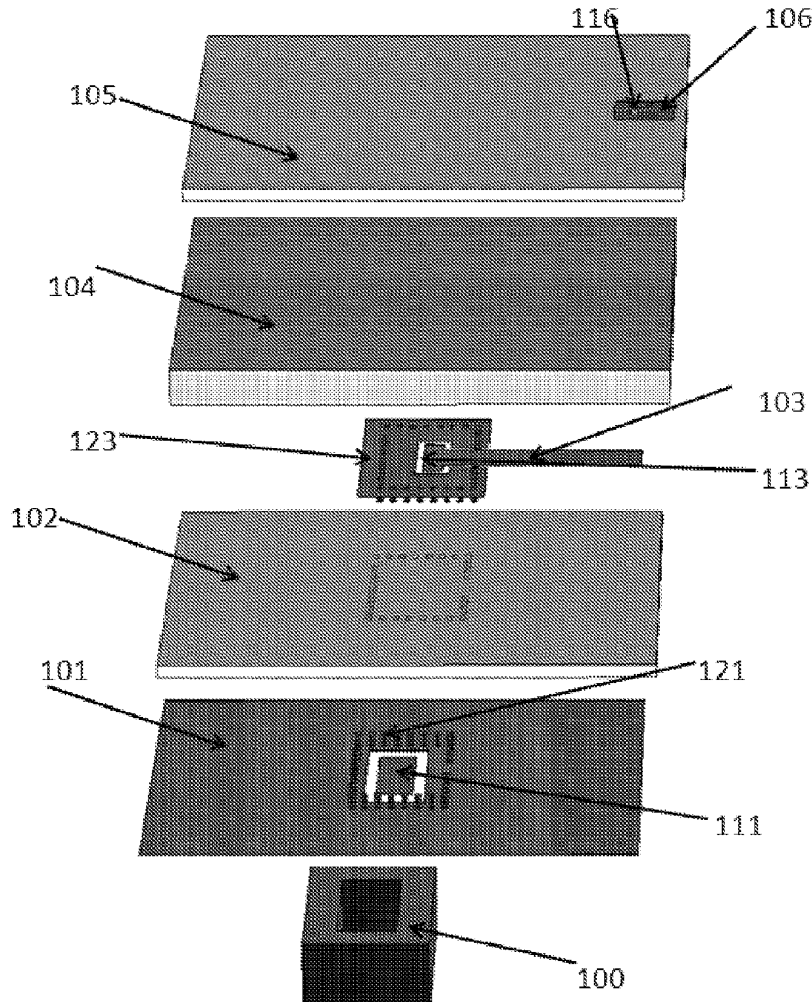
§ 371 (c)(1),
(2) Date: **May 27, 2022**

(30) **Foreign Application Priority Data**

Nov. 30, 2019 (IN) 201931030816

(57) **ABSTRACT**

The present invention discloses a broadband microstrip patch antenna (106) with U-shaped slot (116) with unequal arms for millimeter wave communications. The electromagnetic coupled type feed is used with microstrip line (103) printed on another substrate layer to minimize feed loss. The dimension of the patch, position and dimension of slots, height of dielectric layer, length, width of the microstrip line and so on are optimized to achieve the desired impedance and gain pattern over the 60 GHz frequency band.





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(19) **United States**

(12) **Patent Application Publication**
CHOI et al.

(10) **Pub. No.: US 2022/0416402 A1**

(43) **Pub. Date: Dec. 29, 2022**

(54) **ANTENNA-INSERTED ELECTRODE
STRUCTURE AND IMAGE DISPLAY DEVICE
INCLUDING THE SAME**

(52) **U.S. Cl.**
CPC **H01Q 1/2266** (2013.01); **G06F 3/0446**
(2019.05); **G06F 3/0448** (2019.05); **G06F**
3/0443 (2019.05); **G06F 3/04164** (2019.05);
G06F 3/0412 (2013.01); **G06F 2203/04111**
(2013.01); **G06F 2203/04112** (2013.01)

(71) Applicant: **DONGWOO FINE-CHEM CO.,
LTD.**, Jeollabuk-do (KR)

(72) Inventors: **Byung Jin CHOI**, Incheon (KR); **Jaehyun LEE**, Gyeonggi-do (KR); **Chang Jun MAENG**, Gyeonggi-do (KR)

(57) **ABSTRACT**

(21) Appl. No.: **17/895,262**

(22) Filed: **Aug. 25, 2022**

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2021/000435, filed on Jan. 13, 2021.

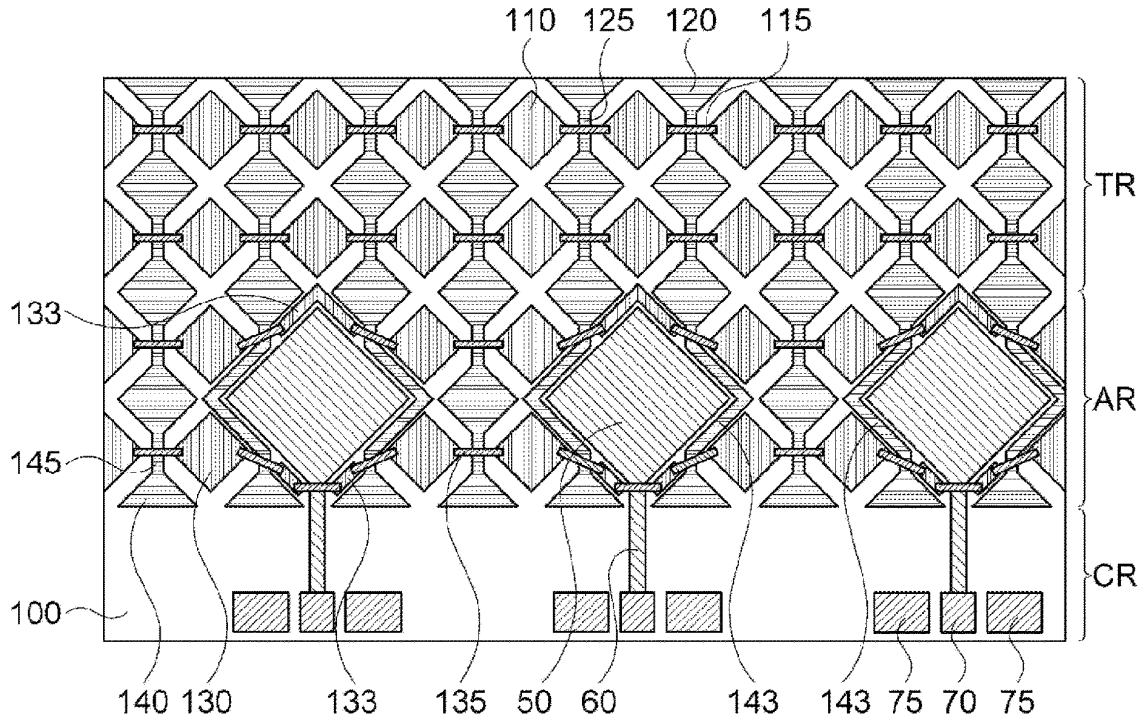
Foreign Application Priority Data

Feb. 25, 2020 (KR) 10-2020-0022987

Publication Classification

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
G06F 3/044 (2006.01)
G06F 3/041 (2006.01)

An antenna-inserted electrode structure of an embodiment includes a substrate layer including a touch sensing region and an antenna-touch sensing region, first sensing electrodes arranged in the touch sensing region of the substrate layer, second row sensing electrodes and second column sensing electrodes arranged in the antenna-touch sensing region of the substrate layer, second bridge electrodes configured to connect the second row sensing electrodes adjacent to each other in a row direction, second connection parts configured to connect the second column sensing electrodes adjacent to each other in a column direction, and antenna units. The antenna units respectively include radiators which are disposed in the antenna-touch sensing region of the substrate layer, have an area larger than each of the second row sensing electrode and the second column sensing electrode, and are disposed by avoiding the second bridge electrodes and the second connection parts in a planar direction.





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(19) **United States**

(12) **Patent Application Publication**
HARPER et al.

(10) **Pub. No.: US 2022/0416405 A1**

(43) **Pub. Date: Dec. 29, 2022**

(54) **COIL-DRIVEN NEAR FIELD COMMUNICATIONS ANTENNA**

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 7/00** (2013.01); **H04W 4/80** (2018.02)

(71) Applicant: **Microsoft Technology Licensing, LLC**,
Redmond, WA (US)

(57) **ABSTRACT**

(72) Inventors: **Marc HARPER**, Snohomish, WA (US);
Apoorva SHARMA, Kenmore, WA (US)

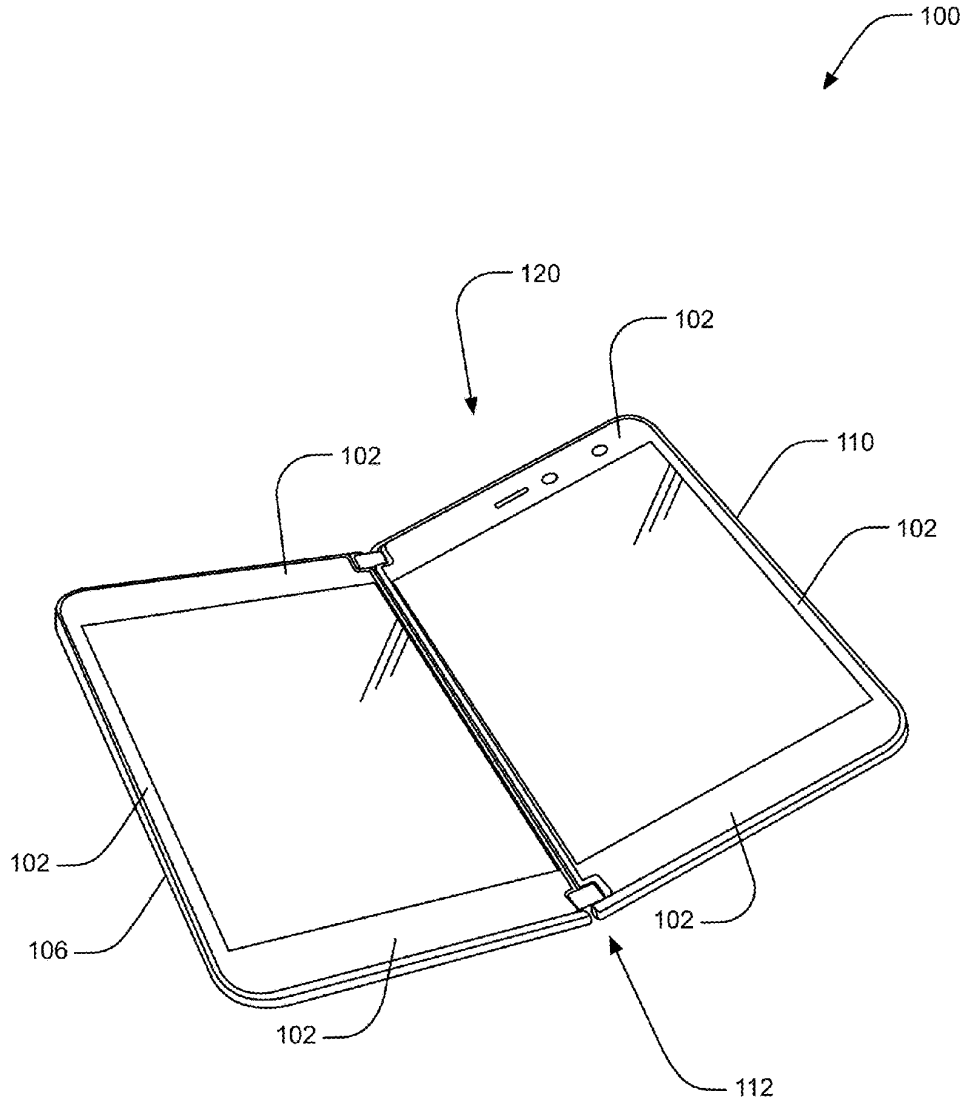
A communication device includes a conductive chassis, an electrical feed positioned within the conductive chassis and configured to supply a communication signal, an edge antenna at least partially formed in the conductive chassis at an edge of the communication device, and a conductive coil positioned within the conductive chassis in proximity to the edge antenna. The conductive coil is configured to receive the communication signal from the electrical feed and to generate a magnetic field corresponding to the communication signal that inductively drives the edge antenna to radiate a radio frequency signal corresponding to the communication signal.

(21) Appl. No.: **17/355,616**

(22) Filed: **Jun. 23, 2021**

Publication Classification

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)
H04W 4/80 (2006.01)





US 20220416410A1

(19) **United States**

(12) **Patent Application Publication**
KIM et al.

(10) **Pub. No.: US 2022/0416410 A1**

(43) **Pub. Date: Dec. 29, 2022**

(54) **ANTENNA STRUCTURE**

Publication Classification

(71) Applicant: **DONGWOO FINE-CHEM CO., LTD.**, Jeollabuk-do (KR)

(51) **Int. Cl.**
H01Q 1/42 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/38 (2006.01)

(72) Inventors: **Young Ju KIM**, Gyeonggi-do (KR);
Yoon Ho HUH, Seoul (KR); **Hee Jun PARK**, Gyeonggi-do (KR); **Young Su LEE**, Gyeonggi-do (KR); **In Kak SONG**, Daejeon (KR); **Dong Pil PARK**, Incheon (KR)

(52) **U.S. Cl.**
CPC *H01Q 1/422* (2013.01); *H01Q 1/2283* (2013.01); *H01Q 1/38* (2013.01)

(57) **ABSTRACT**

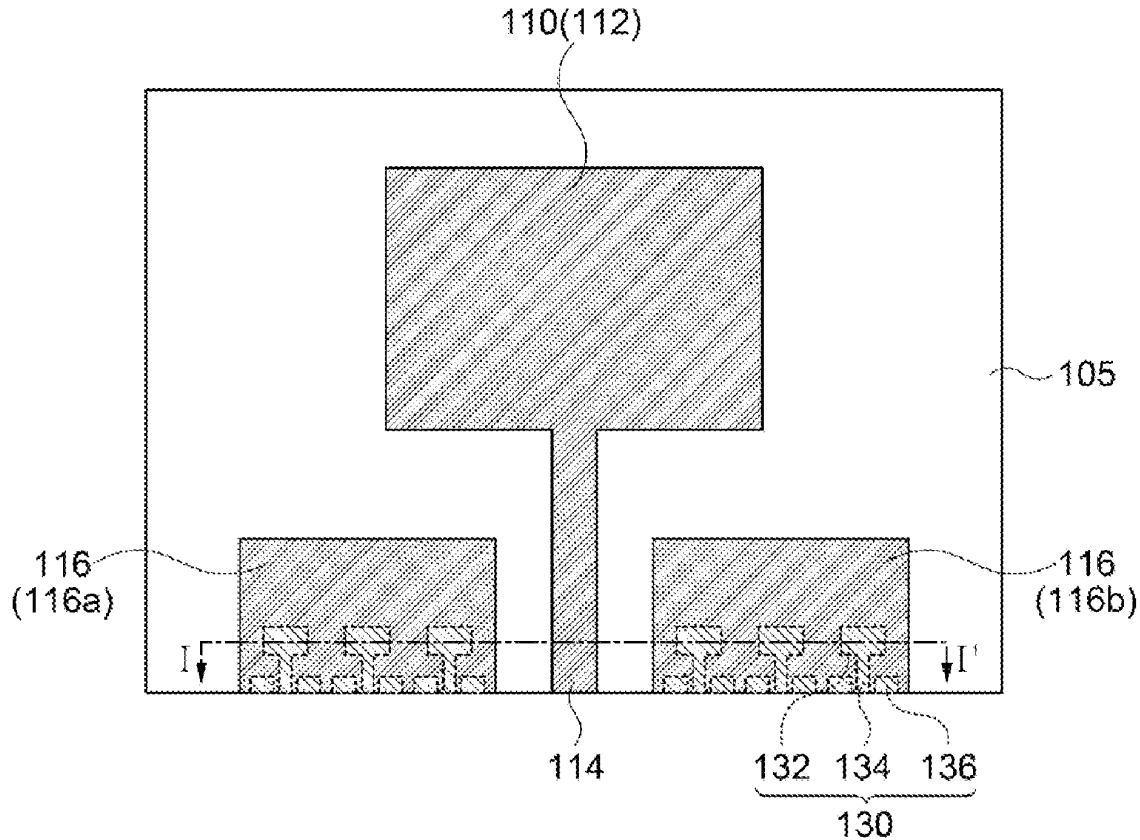
An antenna structure according to an embodiment of the present invention includes a first antenna unit including a first radiator, a first transmission line connected to the first radiator, and a guide pattern disposed around the first transmission line and separated from the first transmission line, a second antenna unit at least partially covered by the guide pattern of the first antenna unit in a plan view, and a dielectric layer interposed between the first antenna unit and the second antenna unit. An antenna structure implementing low-frequency and high-frequency properties with high reliability is provided.

(21) Appl. No.: **17/848,888**

(22) Filed: **Jun. 24, 2022**

(30) **Foreign Application Priority Data**

Jun. 25, 2021 (KR) 10-2021-0083376
Jul. 22, 2021 (KR) 10-2021-0096303





US 20220416834A1

(19) **United States**

(12) **Patent Application Publication**
You et al.

(10) **Pub. No.: US 2022/0416834 A1**

(43) **Pub. Date: Dec. 29, 2022**

(54) **ANTENNA APPARATUS, COMMUNICATION PRODUCT, AND ANTENNA PATTERN RECONSTRUCTION METHOD**

H01Q 1/48 (2006.01)
H01Q 1/50 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/24 (2006.01)
H01Q 13/10 (2006.01)
H01Q 25/00 (2006.01)

(71) Applicant: **Huawei Technologies Co., Ltd.**,
Shenzhen (CN)

(72) Inventors: **Jiaqing You**, Shanghai (CN); **Jikang Wang**, Shanghai (CN); **Laiwei Shen**, Shanghai (CN)

(52) **U.S. Cl.**
CPC *H04B 1/401* (2013.01); *H04B 17/318* (2015.01); *H01Q 1/48* (2013.01); *H01Q 1/50* (2013.01); *H01Q 1/2291* (2013.01); *H01Q 1/243* (2013.01); *H01Q 13/103* (2013.01); *H01Q 25/00* (2013.01)

(21) Appl. No.: **17/641,380**

(22) PCT Filed: **Aug. 25, 2020**

(86) PCT No.: **PCT/CN2020/111012**

§ 371 (c)(1),

(2) Date: **Mar. 8, 2022**

(57) **ABSTRACT**

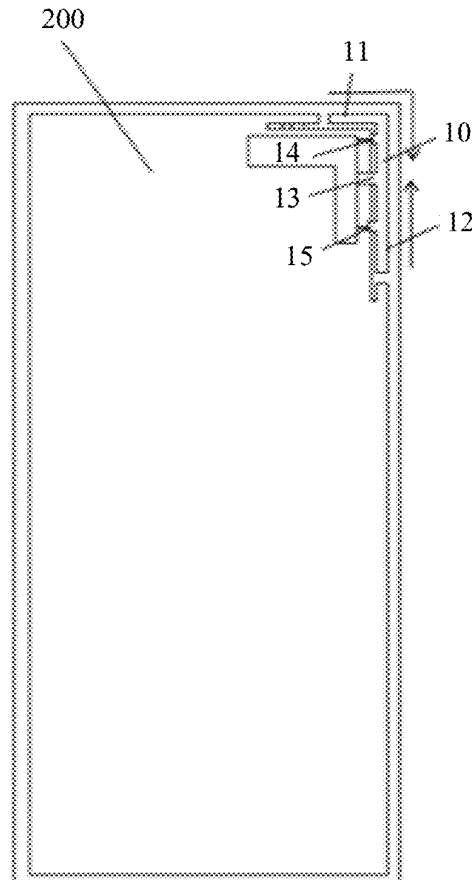
An antenna apparatus having an antenna. The antenna comprises a first radiator section and a second radiator section coupled to each other, and a third radiator section, a fourth radiator section, and a fifth radiator section that are distributed on a same side of the first and second radiator sections, wherein the third radiator section is coupled to a junction of the first and second radiator sections and is grounded, and the fourth and fifth radiator sections are separately disposed on two sides of the third radiator section, wherein the fourth radiator section is grounded by a first switch, and the fifth radiator section is grounded by a second switch.

(30) **Foreign Application Priority Data**

Sep. 12, 2019 (CN) 201910866772.6

Publication Classification

(51) **Int. Cl.**
H04B 1/401 (2006.01)
H04B 17/318 (2006.01)





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(19) **United States**

(12) **Patent Application Publication**
Wu et al.

(10) **Pub. No.: US 2023/0006333 A1**

(43) **Pub. Date: Jan. 5, 2023**

(54) **ANTENNA APPARATUS AND ELECTRONIC DEVICE**

Publication Classification

(71) Applicant: **Huawei Technologies Co., Ltd.**,
Shenzhen (CN)

(72) Inventors: **Pengfei Wu**, Shanghai (CN); **Hanyang Wang**, Reading (GB); **Dong Yu**,
Shanghai (CN)

(21) Appl. No.: **17/780,857**

(22) PCT Filed: **Nov. 27, 2020**

(86) PCT No.: **PCT/CN2020/132206**

§ 371 (c)(1),
(2) Date: **May 27, 2022**

(30) **Foreign Application Priority Data**

Nov. 28, 2019 (CN) 201911192854.3
Jan. 22, 2020 (CN) 202010075891.2

(51) **Int. Cl.**

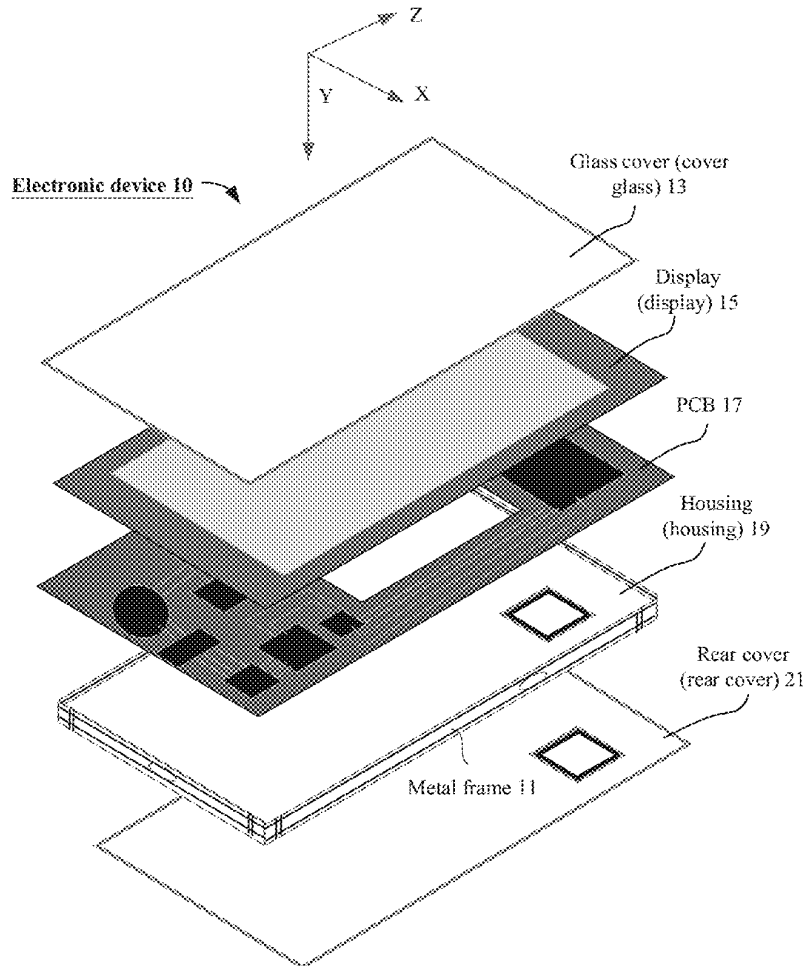
H01Q 1/24 (2006.01)
H01Q 1/36 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/50 (2006.01)
H01Q 13/08 (2006.01)
H01Q 13/10 (2006.01)
H01Q 5/20 (2006.01)

(52) **U.S. Cl.**

CPC **H01Q 1/243** (2013.01); **H01Q 1/36**
(2013.01); **H01Q 1/48** (2013.01); **H01Q 1/50**
(2013.01); **H01Q 13/08** (2013.01); **H01Q 13/10** (2013.01); **H01Q 5/20** (2015.01)

(57) **ABSTRACT**

In an antenna design, a metal frame of an electronic device and a printed circuit board (PCB) form a slot antenna radiator, where two common mode (CM) slot antenna modes of the slot antenna radiator are excited through anti-symmetrical feeding, so that when dual resonances and wide-band coverage are implemented, specific absorption ratio (SAR) values in the two CM slot antenna modes are close.





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(19) **United States**

(12) **Patent Application Publication**
YANG

(10) **Pub. No.: US 2023/0006335 A1**

(43) **Pub. Date: Jan. 5, 2023**

(54) **ANTENNA ASSEMBLY AND ELECTRONIC DEVICE**

(71) Applicant: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.**, Dongguan (CN)

(72) Inventor: **Fan YANG**, Dongguan (CN)

(73) Assignee: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.**, Dongguan (CN)

(21) Appl. No.: **17/940,973**

(22) Filed: **Sep. 8, 2022**

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2021/073567, filed on Jan. 25, 2021.

(30) **Foreign Application Priority Data**

Mar. 12, 2020 (CN) 202010169497.5
Mar. 12, 2022 (CN) 202020306585.0

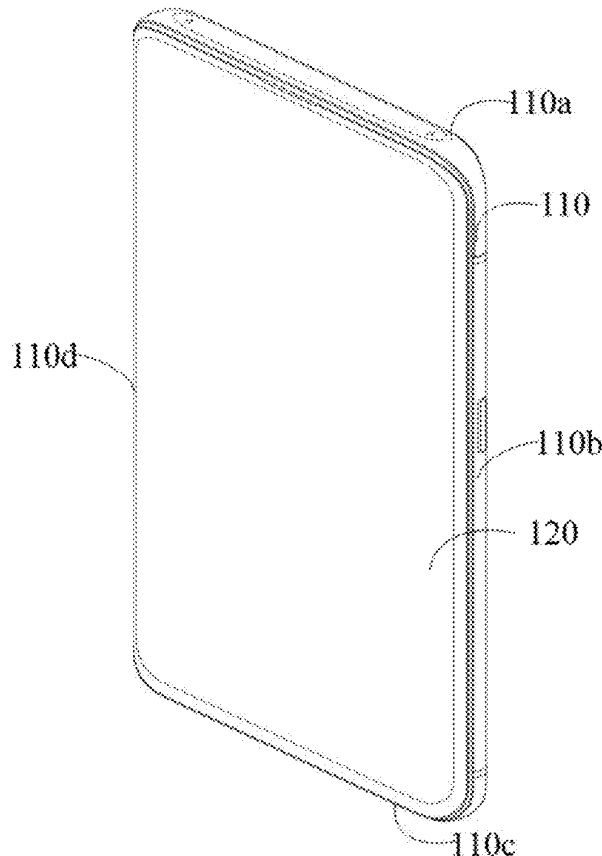
Publication Classification

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 9/30 (2006.01)
(52) **U.S. Cl.**
CPC *H01Q 1/243* (2013.01); *H01Q 1/38* (2013.01); *H01Q 9/30* (2013.01)

(57) **ABSTRACT**

An antenna assembly includes a conductive frame, a filter module, and a feeding module. The conductive frame defined at least one gap. The gap divides the conductive frame into a first conductive branch with a first feeding point and a second conductive branch with a second feeding point. The first feed circuit is to feed an adjustable first current signal to the first conductive branch via the first filter circuit and the first feeding point, so that a first radiator on the first conductive branch is adjustable to radiate a first signal. The second feed circuit is to feed a second current signal to the second conductive branch via the second filter circuit and the second feeding point, and a second radiator on the second conductive branch radiates a second signal. An electronic device is also provided.

10





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(19) **United States**

(12) **Patent Application Publication**
Yang

(10) **Pub. No.: US 2023/0006336 A1**

(43) **Pub. Date: Jan. 5, 2023**

(54) **ANTENNA ASSEMBLY AND ELECTRONIC DEVICE**

Publication Classification

(71) Applicant: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.**, Dongguan (CN)

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 9/30 (2006.01)

(72) Inventor: **Fan Yang**, Dongguan (CN)

(52) **U.S. Cl.**
CPC *H01Q 1/243* (2013.01); *H01Q 1/38* (2013.01); *H01Q 9/30* (2013.01)

(21) Appl. No.: **17/941,001**

(57) **ABSTRACT**

(22) Filed: **Sep. 8, 2022**

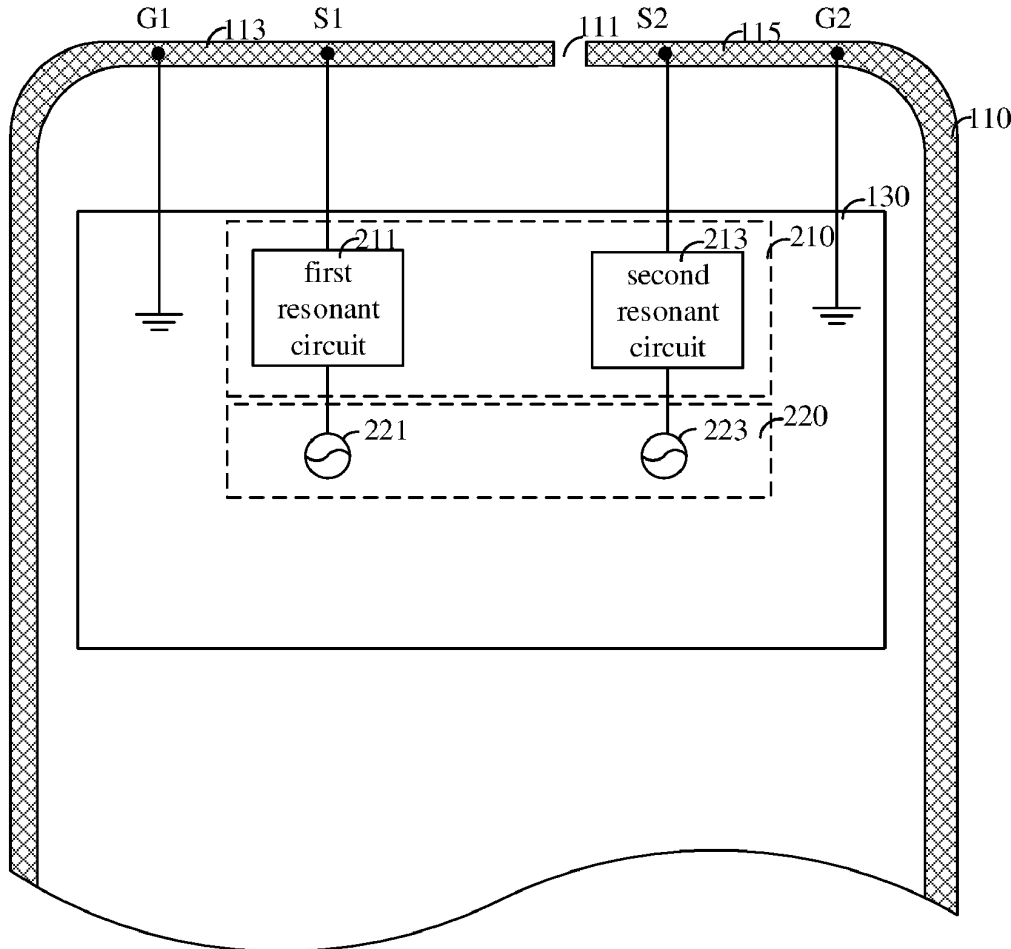
An antenna assembly may include a conductive frame, a resonant module and a signal source module. The conductive frame may define at least one slot, the slot may at least divide the conductive frame into a first conductive branch and a second conductive branch. A first feed point may be provided on the first conductive branch, and a second feed point may be provided on the second conductive branch. The resonant module may include a first resonant circuit and a second resonant circuit. The first signal source may feed a first current signal to the first conductive branch, to generate a plurality of resonant frequencies on the first conductive branch. The second signal source may feed a second current signal to the second conductive branch via the second resonant circuit and the second feed point, to generate at least one resonant frequency.

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2021/073689, filed on Jan. 26, 2021.

Foreign Application Priority Data

(30) Mar. 12, 2020 (CN) 202010169499.4
Mar. 12, 2020 (CN) 202020306607.3





(19) **United States**

(12) **Patent Application Publication**
Yang

(10) **Pub. No.: US 2023/0006345 A1**

(43) **Pub. Date: Jan. 5, 2023**

(54) **ANTENNA ASSEMBLY AND ELECTRONIC DEVICE**

H01Q 21/30 (2006.01)

H01Q 5/335 (2006.01)

(71) Applicant: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.**, Dongguan (CN)

(52) **U.S. Cl.**
CPC *H01Q 1/50* (2013.01); *H01Q 1/243* (2013.01); *H01Q 21/30* (2013.01); *H01Q 5/335* (2015.01); *H04M 1/0266* (2013.01)

(72) Inventor: **Fan Yang**, Dongguan (CN)

(57) **ABSTRACT**

(21) Appl. No.: **17/941,005**

An antenna assembly includes a conductive frame defining at least one slot and divided into at least a first conductive branch and a second conductive branch independently by the slot, a feed point being arranged on the first conductive branch; a resonant circuit, a signal source being coupled to and feeding a current signal to the first conductive branch through the resonant circuit and the feed point, the current signal being coupled to the second conductive branch through the slot, and multiple resonant frequencies being generated on the first and the second conductive branches through the resonant circuit; and a switching circuit configured between perform a switching adjustment for the current signal coupled to the second conductive branch such that radio frequency signals including multiple operating frequency bands are radiated simultaneously on the first conductive branch and the second conductive branch; at least two operating frequency bands being switchable.

(22) Filed: **Sep. 8, 2022**

Related U.S. Application Data

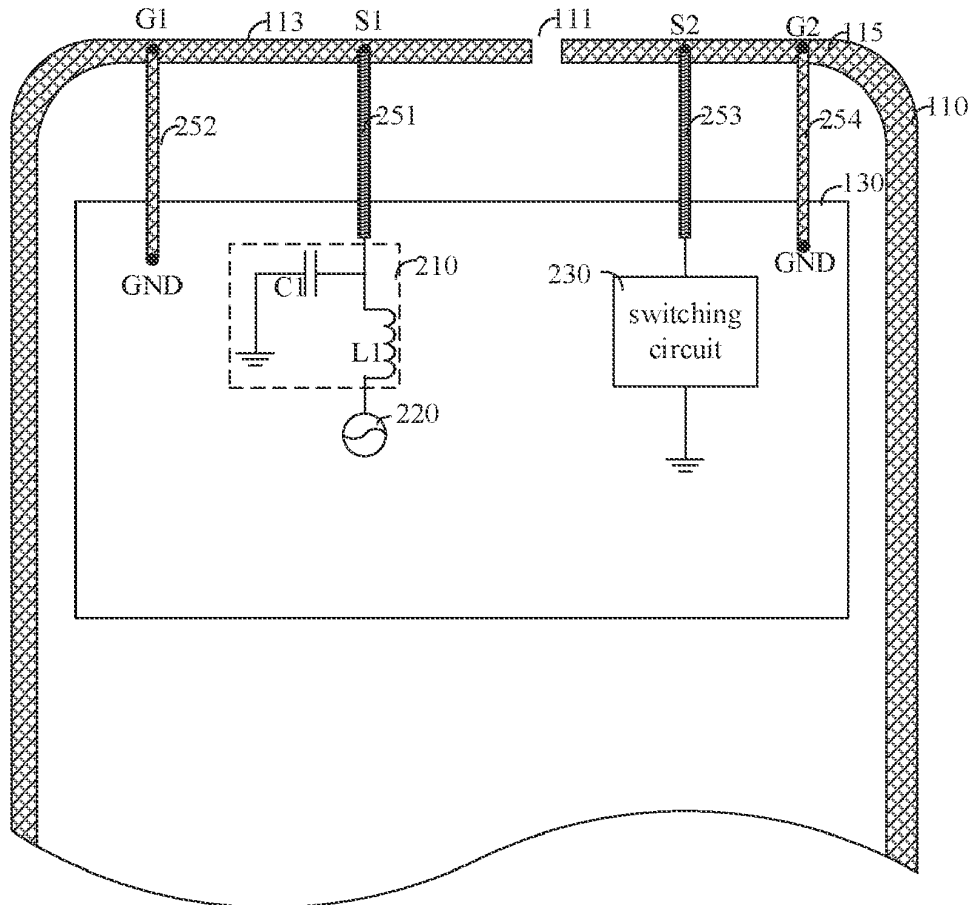
(63) Continuation of application No. PCT/CN2021/073949, filed on Jan. 27, 2021.

(30) **Foreign Application Priority Data**

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(54) **ANTENNA DEVICE AND DISPLAY DEVICE INCLUDING THE SAME**

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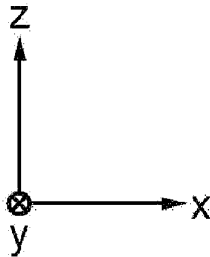
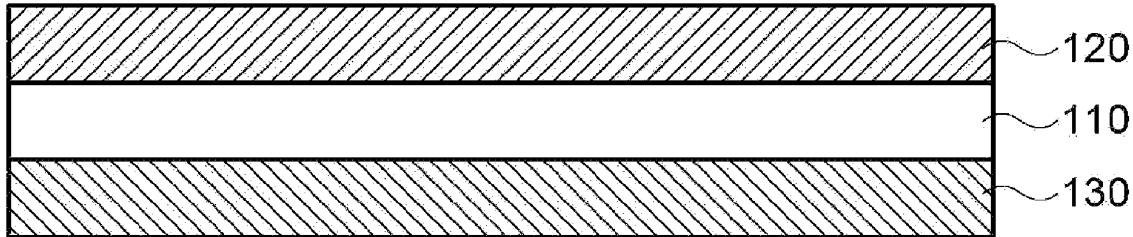
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(57) **ABSTRACT**

An antenna device according to an embodiment includes an array antenna including a plurality of antenna elements, a first flexible printed circuit board (FPCB) including a plurality of first transmission lines which are electrically connected to the plurality of antenna elements and have different lengths, and a radio frequency integrated circuit (RFIC) electrically connected to the plurality of first transmission lines.

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(54) **ANTENNA ASSEMBLY AND ELECTRONIC DEVICE**

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(57) **ABSTRACT**

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Provided is an antenna assembly including a conductive frame, and a resonance unit. The conductive frame is divided into first and second conductive branch by a slot. The resonance unit includes first and second resonance circuits. One terminal of the second resonance circuit is grounded, and another terminal is connected to the second conductive branch. A first signal source is capable of feeding a first current signal to the first conductive branch through the first resonance circuit and the first feeding point, enabling the first conductive branch to radiate a first radio frequency signal. The second signal source is capable of feeding a second current signal to the second conductive branch through the second feeding point, enabling the second conductive branch, under a resonance of the second resonance circuit, to radiate a second radio frequency signal.

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